ASSOCIATION OF BAY AREA GOVERNMENTS
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March, 1972

Enclosed is the report, Airport Noise and Land Use Analysis, prepared for the Regional Airport Systems Study Committee of the Association of Bay Area Governments, by Paul K. Dygert, Judy A. Ungerer, and Fred L. Collins, (October 1971 and revised in March 1972).

This is a working paper discussing land use and noise contour data. Data cards were keypunched for the San Francisco, Oakland, and San Jose airports. The computer program and tapes are available for application to other airports, and may be obtained from the offices of the Regional Airport Systems Study, at the above address.

Yours very truly,

Walter E. Gillfillan

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REGIONAL AIRPORT SYSTEMS STUDY

ENVIRONMENTAL STUDIES

AIRPORT NOISE AND LAND USE ANALYSIS

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OCTOBER 1971

This report was prepared for the Regional Airport Systems Study; the preparation of this report was financed in part from an urban planning grant from the Department of Housing and Urban Development, under the provisions of Section 701 of the Housing Act of 1954, as amended.

TABLE OF CONTENTS

		PAGE	
I.	INTRODUCTION		
	Background and Motivation	1-1	
	Objectives of the Analysis	1-5	
	Scope of the Analysis	1-6	
	Plan of the Report	1-7	
II.	COORDINATE GRID SYSTEM AND NOISE CONTOURS		
	Choice of the Grid System	2-1	
	Relationship to the California Plane Coordinate System	2-1	
	Noise Contours	2-2 to 2-3	
III.	PROCEDURES FOR LAND USE DATA ACQUISITION		
	Sources	3-1	
	Methods	3-1 to 3-3	
IV.	APPLICATIONS AND EXTENSIONS		
	Current Results	4-1	
	Use in Airport Project Appraisal	4-1	
	Appraisal of New Runway Proposals	4-2	
	Alternative Patterns of Traffic Growth	4-3	
	New Airport Sites	4-3	
	Other Applications	4-4	
	Land Use Tables		Table Number
	San Francisco-1970	4-5	4-1
	San Francisco-1985	4-6	4-2
	Oakland-1970	4-7	4-3
	Oakland-1985	4-8	4-4
	San Jose-1970	4-9	4-5
	San Jose-1985	4-10	4-6

LIST OF FIGURES

		Follows Page...
1.	U.S.G.S. topographic map	2-2
2.	SFO-1970	2-2
3.	SFO-1985	2-2
4.	OAK-1970	2-2
5.	OAK-1985	2-2
6.	SJC-1970	2-2
7.	SJC-1985	2-2
8.	Grid system superimposed on aerial photograph	3-2

APPENDIX A--LAND USE ALLOCATION PROGRAM

Computer Program Writeup
Chart of Possible Cuts
Output chart
Program Listing

I. INTRODUCTION

This report describes and draws together two separate but related activities which were undertaken to provide a tool for the evaluation of changes in aircraft noise around airports. The two activities involved, first, the development of extensive and detailed data on land uses around the three major air carrier airports in the area encompassed by the Regional Airport Systems Study; and, secondly, the creation of a computer-based system for manipulating the data so that it can be conveniently used for the study of alternative airport development plans.

As inputs, the analysis reported on here uses the noise contours computed for the Regional Airport Systems Study by Bolt, Beranek, and Newman [1] and detailed land use data prepared by the Regional Airport Systems Study. The computer program for merging the land-use data and the noise contours was prepared by Fred L. Collins Associates.

BACKGROUND AND MOTIVATION

It is obvious from even casual observation that one of the principal issues in airport planning, development, and operation is the noise imposed on communities surrounding airports. Accordingly, it is essential that any set of procedures for evaluating alternative airport development policies include a method for appraising the different noise levels and patterns implied by the policy alternatives. Techniques for measuring noise levels around airports are well advanced, and several indices are in use throughout the world. One procedure is that developed by Bolt, Beranek, and Newman for the computation of a "noise exposure forecast" (NEF); and it is this approach which has been used in their analysis for the Regional Airport Systems Study: The NEF computation procedure allows one to estimate the noise level at any point on the ground in the vicinity of an airport from some data on aircraft type, runway utilization, the number of flights,

1 Bolt, Beranek and Newman, Aviation Noise Evaluations and Projections, San Francisco Bay Region (Canoga Park, Calif, 1971).

I. INTRODUCTION

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As input, the analysis depended on data from the noise contours computed for the Regional Airport Systems Study by Bolt, Beranek, and Newman[1] and detailed land use data compiled by the Regional Airport Systems Study. The computer program for merging the land-use data and the noise contours was prepared by Fred L. Collins Associates.

AIRCRAFT NOISE EVALUATION

It is evident from even casual observation that one of the principal issues in airport planning, development, and operation is the noise imposed on communities surrounding airports. Accordingly, it is essential that any set of procedures for evaluating alternative airport development policies include a method for measuring the different noise levels and patterns implied by the policy alternatives. Techniques for measuring noise levels around airports are well established, and several indices are in use throughout the world. One procedure is that developed by Bolt, Beranek, and Newman for the computation of a Noise Exposure Forecast (NEF), and it is this approach which has been used in their analysis for the Regional Airport Systems Study. The NEF computation procedure allows one to estimate the noise level at any point on the ground, taking account of the aircraft types operating at airport facilities, runway utilization, the number of flights,

1 Bolt, Beranek and Newman, Airports: Noise Evaluations and Environmental Considerations, Bay Region (Canoga Park, Calif., 1970).

and the time of day of operations. But the still unresolved problem is that of placing some valuation on the differential noise effects which result from alternative airport development policies.

The effect of aircraft noise depends heavily on the activities which are exposed to it; that is, on the land uses which lie within the noise impact area. For the most part, industrial, commercial, agricultural, and some recreational activities are relatively immune to the effects of noise, although one could find exceptions in each category.[2] But the major problem occurs for residential use.

Ideally, one would like a measure of the cost of noise so that those costs could be added to the other costs of airport development and compared with the benefits of alternative development policies.

Conceptually, the costs which aircraft noise impose on commercial and industrial activities are analogous to the costs imposed on residential activities.[3] In the first case, the noise affects the nature of production processes by requiring insulation of buildings or other preventive measures to eliminate the adverse effects of the noise. In the case of residential activities, noise reduces the usefulness of the property by making it less enjoyable to residents. The industrial/commercial and the residential cases represent two very different measurement problems, however. The first can be measured in terms of production losses, or increased production costs. But measurement of the noise impact on residential properties requires some approach to the measurement of loss of satisfaction from residential property, and this is conceptually a more difficult problem. At the present time, no adequate measurement of the dollar cost of a unit increment of airport noise has been devised. A number of research efforts have been accomplished, or are proceeding, but the results to date are not particularly encouraging. Research on the measurement of the cost of noise has proceeded along three lines, but all are based, at least in

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2. A landmark noise case in the United States was Causby vs. the United States in which low-flying aircraft reduced production from Causby's chicken farm.
3. Paul K. Dygert, "An Economic Approach to Airport Noise," Journal of Air Law and Commerce, 30 (Spring, 1964), 214.

part, on measuring changes in real estate values associated with aircraft noise levels.

A 1969 study [4] of a 13-year trend in property values around the Los Angeles International Airport compared two areas which were exposed to noise above 90 PNdB, and two which were not. There were a number of methodological problems with the study; and the analysis revealed no statistically significant differences between the value of those properties exposed to noise and those not exposed. [5]

A second approach was used by the Commission on the Third London Airport (CTLA).[6] Their cost model was a composite of the estimated depreciation in the market values of houses caused by aircraft, the cost of noise annoyance for those persons who remain despite the noise, plus subjective losses not compensated by sale prices for those property owners who decide to leave.

One aspect of the CTLA study bears a resemblance to the land use analysis which is reported here, and deserves some description. The CTLA made a detailed survey of land uses within the estimated noise-affected areas around the proposed airport sites. [7] The overall CTLA surveys covered areas lying within the 35NNI (about 19 NEF) [8] contour; the surveys of commercial, industrial, central government buildings and research establishments were limited to the 50 NNI (bbout 34 NEF) contour; and local authority buildings churches, recreational sites, and sites of historical or scientific interest were only surveyed within the 40 NNI (about 24NEF) contour. The data were collected on one-kilometer grid squares (about 3,281 foot), and a computer program was used to relate the noise contour and land use data.

4. Paul T. McClure, Indicators of the Effect of Jet Noise on the Value of Real Estate (Santa Monica: RAND, 1969).
5. ibid., p. 17
6. Commission on the Third London Airport, Papers and Proceedings, Volume VII, (London: HMSO, 1970), Chs. 18-24.
7. ibid., Ch. 19.
8. NNI is approximately equal to NEF + 16. For these and other relationships among noise measurement indices, see Tracor, Community Reaction to Airport Noise, Final Report, Volume I, (Austin, Texas: Tracor, 1970), pp. 43-4.

The principal differences between the CTLA land use survey and the one reported on here are the methods of acquiring land use data, the detail on those data, and the scale of the grid system. The CTLA data were acquired by a detailed survey on the ground; whereas the present study uses maps and aerial photography. Moreover, the present survey was established on a 250 foot grid system, or less than one-tenth that of the CTLA study.

Still a third approach to the problem of measuring the costs of aircraft noise has been used in studies in Minneapolis-St. Paul and in the San Francisco Bay Area. In a 1969 study, Emerson attempted to define the determinants of residential property value for a sample of 222 individual properties around Minneapolis-St. Paul International Airport.[9] The explanatory variables were related to the characteristics of specific properties and thus contained such items as size of lot, size of house, type of construction, furnishings, measures of accessibility, and others, including freedom from aircraft nuisance. Aircraft noise was found to be a statistically significant variable for CNR levels of 120-125 (NEF 48-53).[10]

In a 1970 study, Dygert and Sanders used census tracts as the unit of observation and analyzed the effect of noise on residential property values in San Mateo County, around San Francisco International Airport.[11] The analysis used average assessed residential property values as a proxy for market price and attempted to explain those values in terms of neighborhood, accessibility, and site characteristics, including aircraft noise levels. An expanded study by Dygert and Hagerer, including San Francisco International and San Jose Municipal Airports and Moffett Naval Air Station as sources of aircraft noise, is currently in progress.

9. Frank Creighton Emerson, The Determinants of Residential Value with Special Reference to the Effects of Aircraft Nuisance and Other Environmental Features (Ann Arbor: Univ. Microfilms, 1969).
10. CNR is approximately equal to NEF + 72; Tracor, loc. cit.
11. Paul K. Dygert and David L. Sanders, "On measuring the Cost of Noise from Subsonic Aircraft," in Robt. Horonjeff and Walter E. Soroka, Transportation System Noise Generation, Propagation and Alleviation, Phase I-Part I (Washington: Dept. of Transportation, Office of Noise Abatement, 1970).

Although some progress is being made in attempts to measure the costs of aircraft noise, it is not obvious that the results from the studies mentioned can be used with any degree of reliability to measure noise costs in the area encompassed by the Regional Airport Systems Study. Lacking the ability to assign dollar values to differential noise exposures, the best operational alternative seemed to be to devise a system for describing the amount and characteristics of the land uses which would be exposed to different noise levels under alternative airport system development policies. This knowledge, combined with some valuation of the relative vulnerability of specific land uses to aircraft noise, provides a gross estimate of the effects of noise on the exposed areas.

OBJECTIVES OF THE ANALYSIS

The analysis described in this report has two principal objectives. The first, and primary, purpose is to provide an analytical tool for describing the effects of changes in the noise characteristics of alternative airport system development policies. As was discussed above, the decision was made that in the current state of knowledge about measuring the costs of aircraft noise around airports, it would be best to simply provide a detailed description of the land uses in the noise affected areas. If, however, the noise effects of alternative development policies are to be taken into account in an evaluation process, it is essential that one be able to describe the effects of the alternatives in a reasonably convenient, efficient, and detailed manner. Such a description is particularly difficult when it is in terms of specific land uses because of the large amount of data which must be manipulated. The primary objective of the analysis has been to provide a data processing system which could be conveniently used in the evaluation of alternative airport system development policies.

The second objective was to provide data on the land uses in the noise affected areas under current conditions. But if a report on current conditions had been the sole objective of the analysis, there would have been no need to use computer processing

of the data. All of the land use data could have been assigned by hand to the appropriate noise contour. Indeed, this was the initial approach of the study. It became quickly apparent, however, that the real usefulness of the land use inventory lay in being able to use it in the evaluation of a number of alternative airport development policies; and this could only be accomplished if the data could be readily manipulated. Clearly, a system for computer processing of the land use inventory and noise contour data was required. It is that system which is described in the subsequent sections of this report.

SCOPE OF THE ANALYSIS

The intent of the analysis has been to provide an analytical capability for noise affected areas in the vicinity of San Francisco International, Metropolitan Oakland International, and San Jose Municipal Airports. For this reason, and because the land use inventory is an extremely laborious and time-consuming activity, the land use data is limited to areas immediately surrounding those three airports.

The scope of the analysis is limited, secondly, to the area lying within the 30 NEF noise contour as computed by Bolt, Beranek, and Newman for the three airports for 1970 and 1985, [12] whichever is more extensive. If analyses are done of other sites, or of runways on existing airports but in materially different locations from the existing runways, the land use inventory will require supplementation. Precisely how this can be accomplished is discussed in detail elsewhere in this report.

Finally, although the point is perhaps obvious, we wish to emphasise that the land use data is based only on a current inventory. There has been no attempt to say anything about future land uses around the airports. The tables in Section IV that record land

12. Bolt, Beranek, and Newman, op. cit., pp. IV - 12, 13, 22, 23, 28, and 29.

uses, and say nothing about what the land uses might actually be in 1985.

PLAN OF THE REPORT

Section II describes the coordinate grid system which was used as the basic tool to relate the land use inventory with the noise contours through the land use allocation program. There is a detailed description of the coordinate grid system, with its positioning described so that the grid can be precisely located at any time there is need to add more data to the land use inventory, Methods for digitizing are also described.

Section III describes the sources of land use data and the method used for recording it. The land uses and their codes are also listed.

Section IV presents the six tables of results based on the present inventory of land uses and the 1970 and 1989 noise contours prepared by Bolt, Beranek, and Newman for San Francisco International, Metropolitan Oakland International, and San Jose municipal airports. In addition, Section IV discusses ways in which the analytic process may be used for different types of airport project evaluation. Some generalized extensions of the process are also indicated.

Appendix A provides a writeup and a copy of the land use allocation program.

II. COORDINATE GRID SYSTEM AND NOISE CONTOURS

The coordinate grid is basic to the analytical process, for it allows the recording of all data in terms of a carefully selected X, Y coordinate system to which the grid is aligned.

CHOICE OF THE GRID SYSTEM

It was noted in Section I that the coordinate grid used for the present analysis is based on a 250 foot cell size, whereas that used for the CTLA analysis, the only known similar study, was one-kilometer. Because of the relatively high density of development in the noise affected areas around the three airports considered in this analysis, it seemed desirable to use a reasonably fine grid. In the processing of the data, the computer can only recognize a grid cell as having a unique land use assigned to it; although the computer has the capability of dividing the cell into two noise levels, as described elsewhere in this report. Since a grid cell had to have a single land use assigned to it, greater accuracy could be achieved with a fine grid. It was this consideration which led us to use the 250 foot square cell.

RELATIONSHIP TO THE CALIFORNIA PLANE COORDINATE SYSTEM

In order to achieve maximum usefulness of the data developed in this analysis, it was decided at the outset that the grid system should be tied to the California Plane Coordinate System. Separate origins were chosen for the grids used at each of the three airports, so each origin had a different latitude and longitude. For each airport, the chosen latitude functioned as the abscissa of the coordinate system, and the chosen longitude as the ordinate. The values of the coordinate system increased in the easterly direction along the abscissa and in a northerly direction along the ordinate. In each case, the origin was designated 500, 500 which allowed the entire noise affected area of each airport to be included within coordinate values between 0 and 999. This choice of origin avoided negative numbers in the

westerly direction along the abscissa and in the southerly direction along the ordinate. In addition, constraining the coordinated values to three digits or less simplifies computer processing, but is not essential to the system.

The coordinate grid was located with reference to the intersection of specific X and Y coordinates in the California Plane Coordinate System, marked on the U.S.G.S. topographic maps. The intersections in the California Plane Cooriinate system were as follows:

AIRPORT	ABSCISSA (LONGITUDE)	ORDINATE (LATITUDE)
San Francisco International	450,000 (122°23'57"W)	420,000 (37°38'19"N)
Oakland International	520,000 (122° 9'27"W)	440,000 (37°41'50"N)
San Jose Municipal	590,000 (121°54'28"W)	310,000 (37°20'36"N)

In the cases of San Francisco International and San Jose Municipal airports, the origin (500,000) of the coordinate grid system coincided with the indicated intersection in the California Plane Coordinate System. In the case of Oakland, however, for convenience, the origin (500,000) of the coordinate grid system was tranlateed along the abscissa 9-1/2" on the photograph (2,375 feet on the ground) west of the referenced intersection of the California Plane Coordinates.

Fig. 1 shows a section of the U.S.G.S. topographic map which includes San Jose Municipal Airport. Two abscissa and two ordinates of the California Plane Coordinate Sysems are shown on the map, and the origin and a portion of the scale of the coordinate grid indicated.

The noise contours used in the analysis were digitized with respect to the particular grid system used at each airport. Computer plots of the contours used in the analysis are presented as Fig. 2 through 7. Digitizeng means, roughly, that the contours were superimposed on the X, Y, coorinate system and the (x,y) values for a large number of points on each contour recorded in digital (numberical) form for later

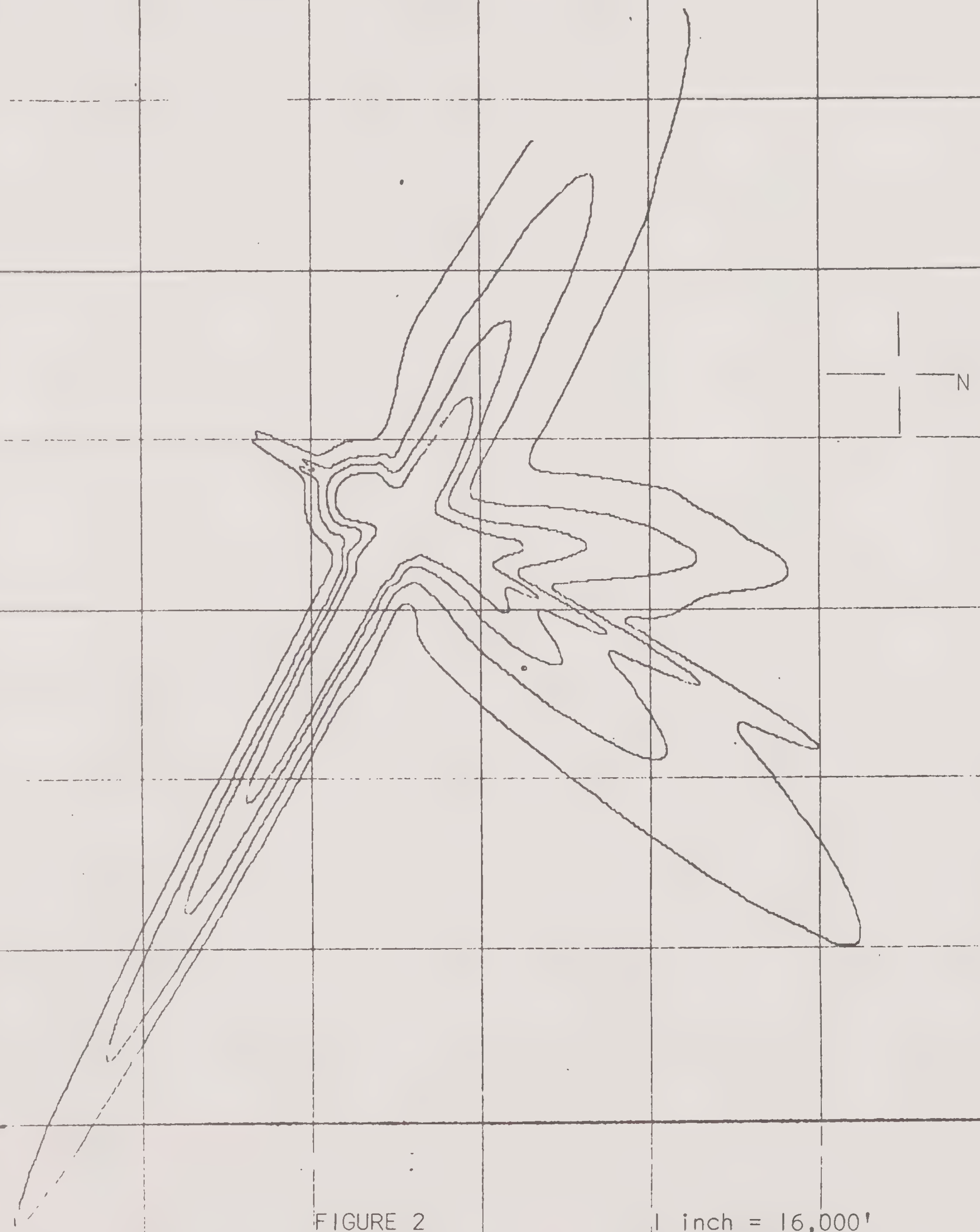
Figure 1 USGS topographic map with California coordinate system and corresponding land use inventory coordinate system

(500,500) = Origin point of land use inventory coordinate system

▬▬▬ = California coordinate system

SAN FRANCISCO AIRPORT

1970



Revised
3/10/72

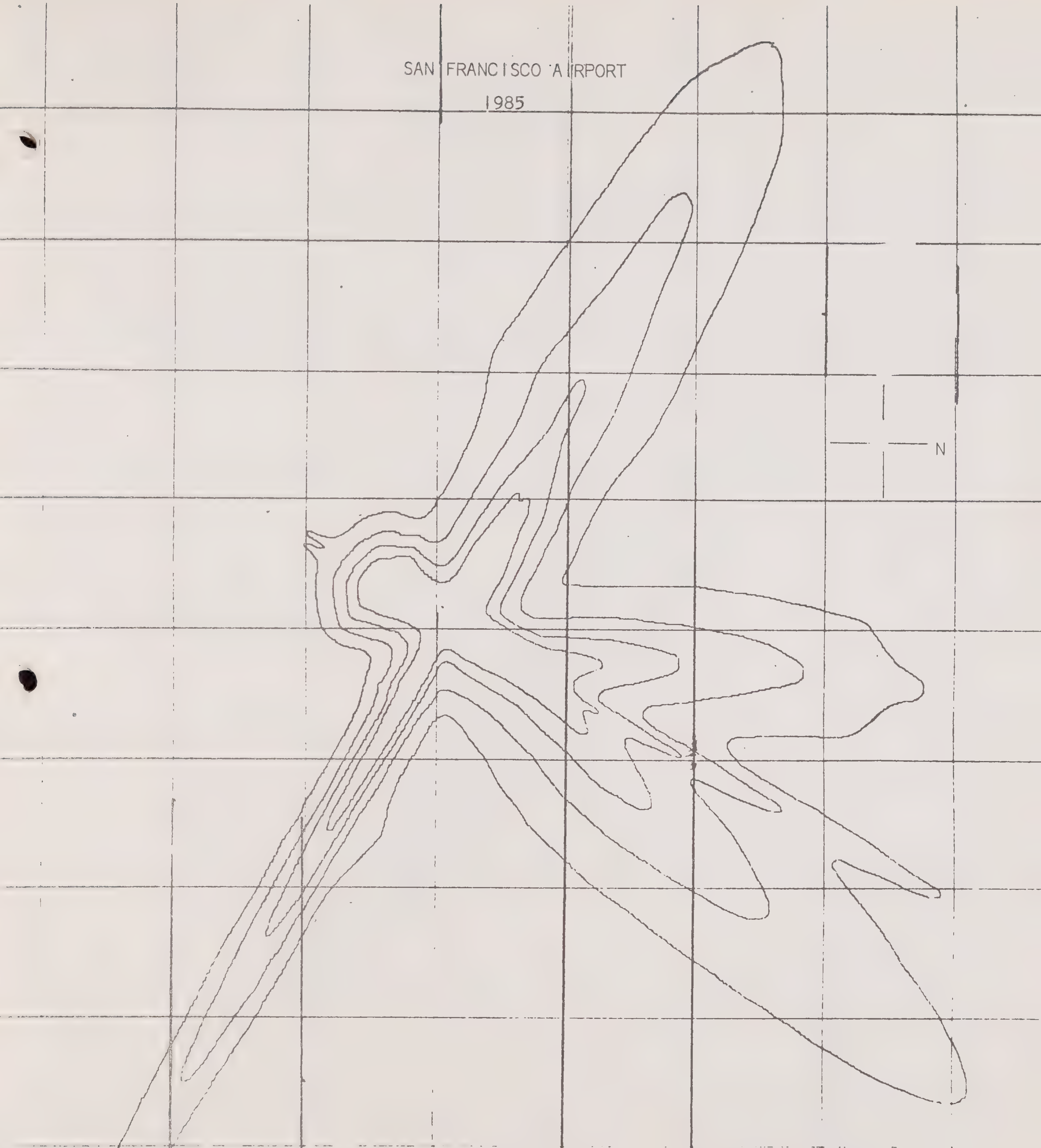
FIGURE 2

1 inch = 16,000'

0 16,000'

SAN FRANCISCO AIRPORT

1985



Revised
5/10/72

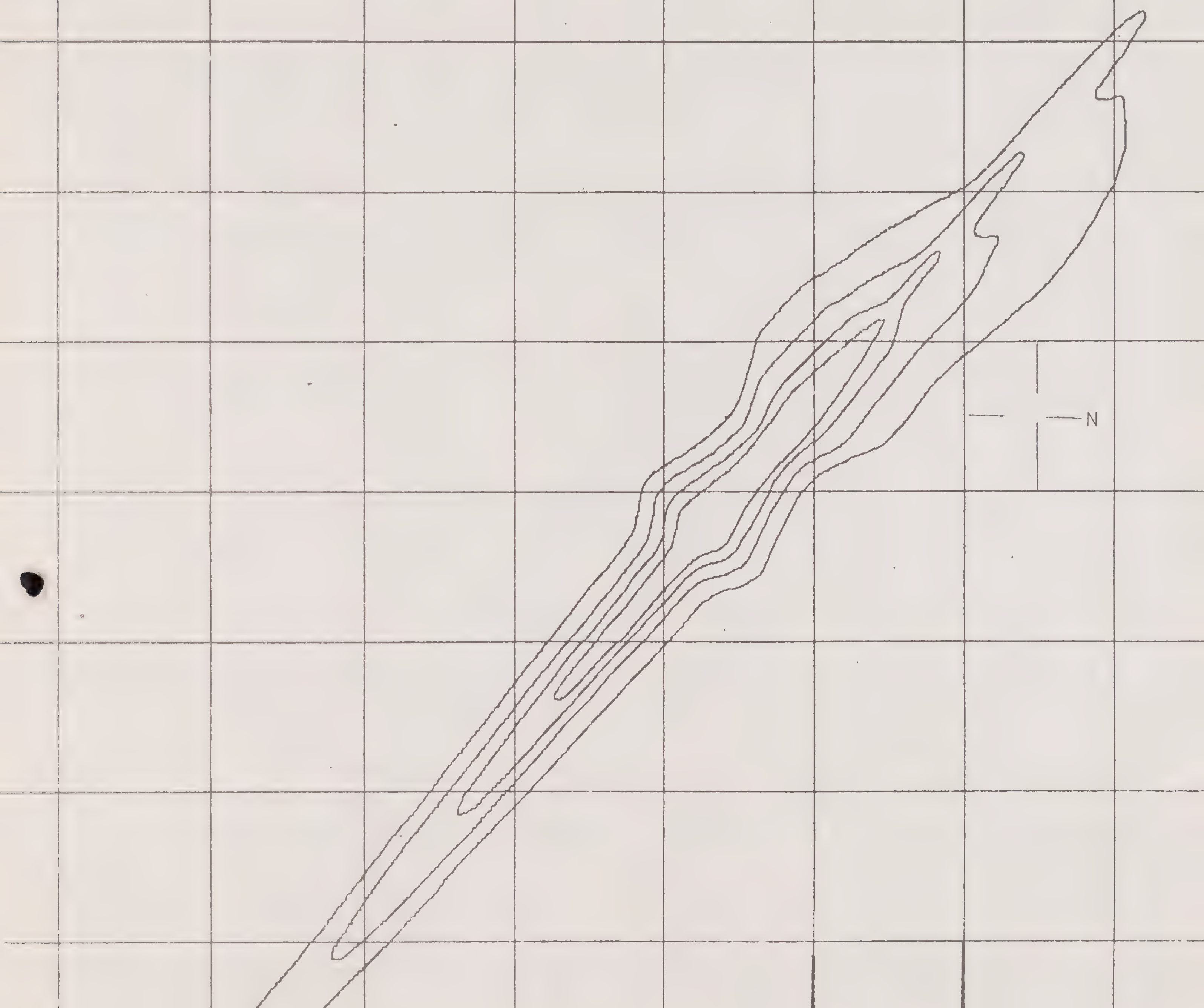
FIGURE 3

1 inch = 8,000'

0 8,000'

OAKLAND AIRPORT

1970



Revised
5/10/72

FIGURE 4

1 inch = 8,000'

0 8,000'

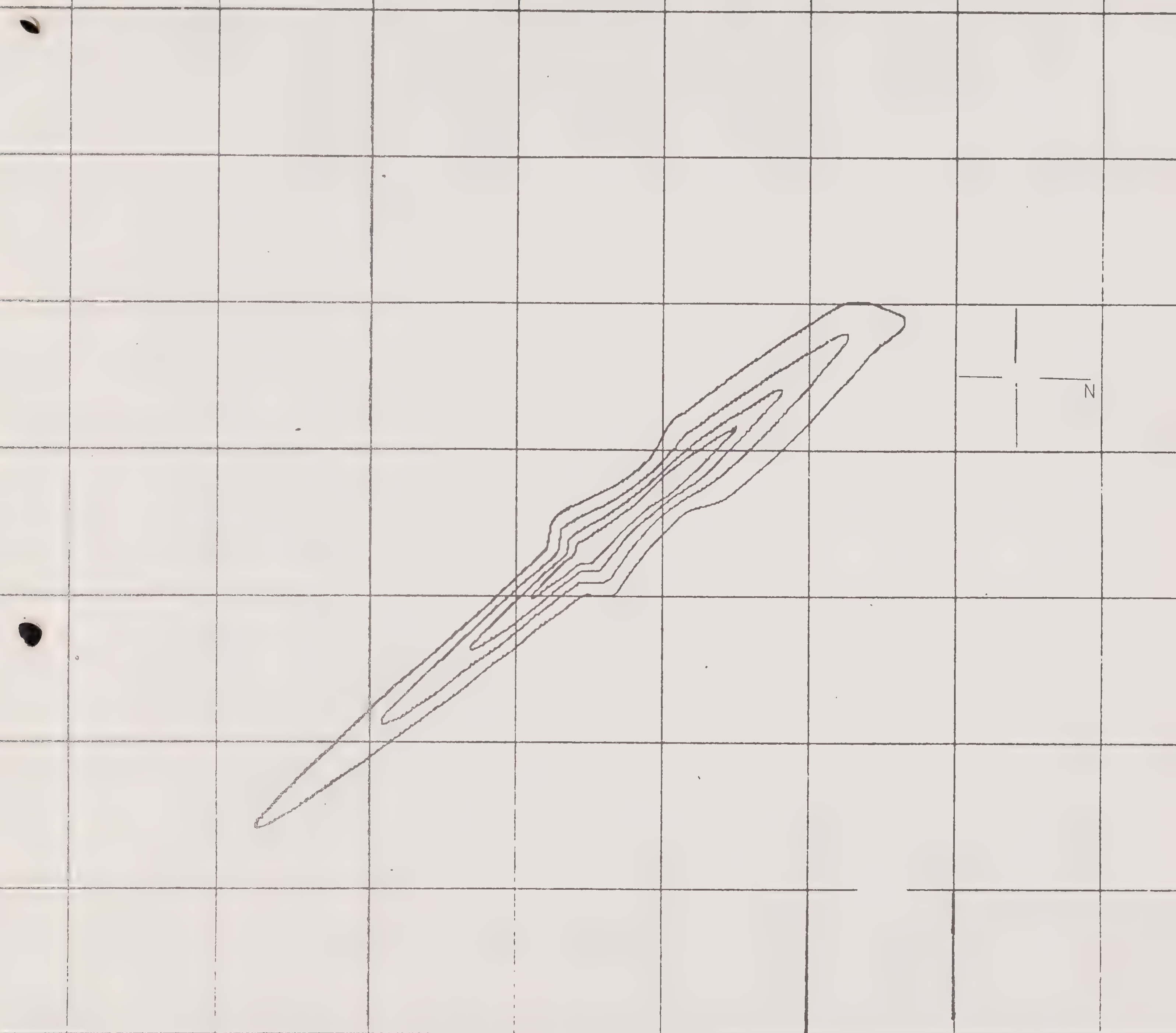
OAKLAND AIRPORT

1985

FIGURE 5

SAN JOSE AIRPORT

1970



Revised

3/10/72

FIGURE 6

1 inch = 8,000'

0 8,000'

SAN JOSE AIRPORT

1985

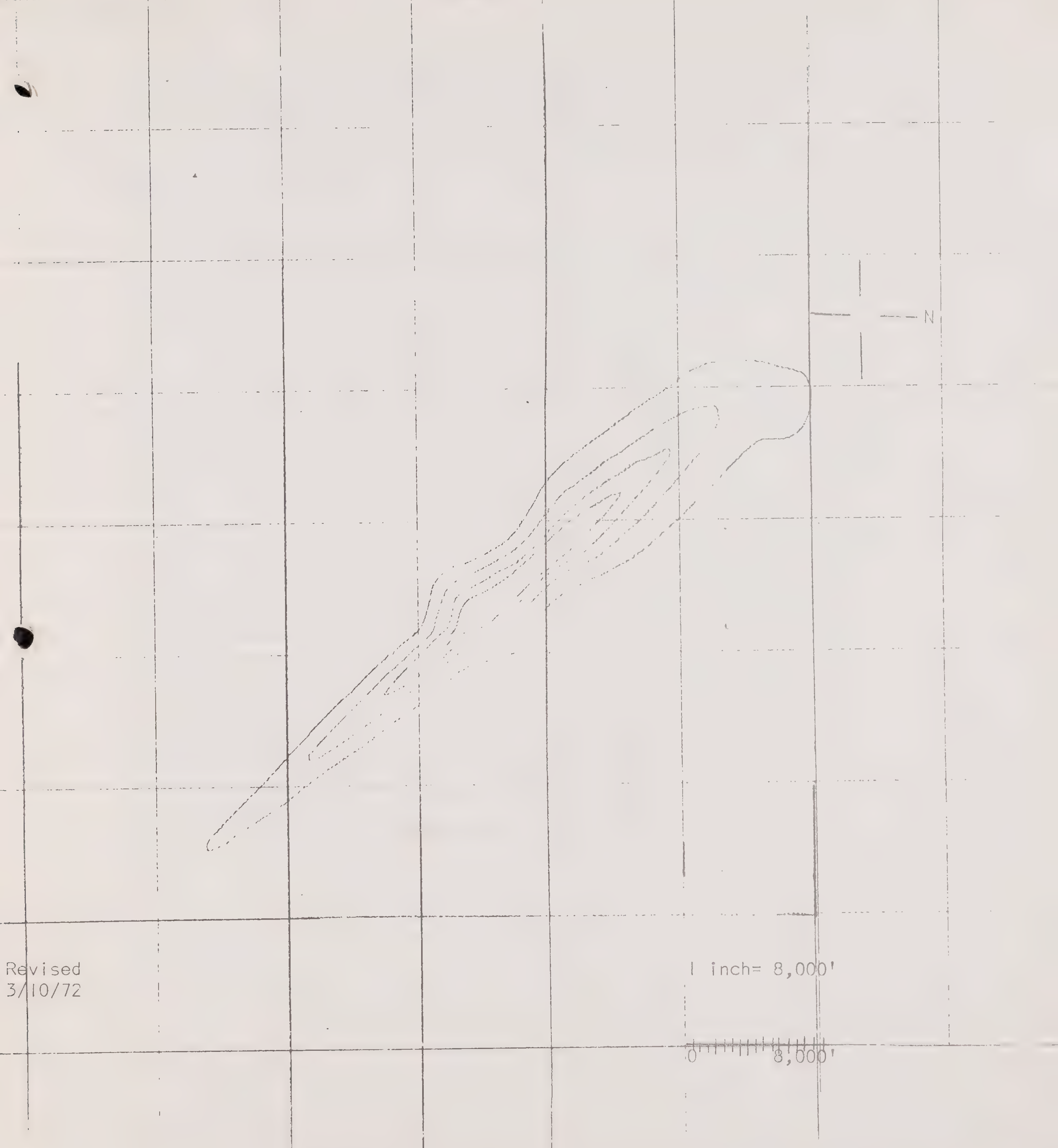


FIG. 7

processing in the land use allocation program. The actual digitizing can be accomplished in at least three ways.

The first way, and the one which was used in the present analysis, used a small-scale drawing of the contours for each airport in a digitizer.

A second, and much more laborious approach would be to determine "by hand" the (x,y) value of each contour level at each point where it cuts an X or Y grid line. This approach would be reasonable to use only in the case where a digitizer was not available.

The third and most flexible approach would be to use the output of a computer program which computes and plots the NEF contours. The computer programs developed and used by Bolt, Beranek, and Newman compute and plot separate NEF contours for each flight path. The separate contours are then merged by a draftsman.[13] The U.S. Department of Transportation, Office of Noise Abatement, however, has had a computer program developed which will merge the separate flight paths and provide an X, Y plot of the final noise contours. The X, Y output of this program should be capable of being used, with the appropriate translation of axes, to provide the X, Y contour values required by the land use allocation program. With these two programs tied together, a complete analysis of the realtionship between aircraft noise and land use under alternative airport development policies could be made simply by entering alternative sets of the data required to compute the NEF contours, along with the file of land use data.

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13. Ibid, p. B-3.

III. PROCEDURES FOR LAND USE DATA ACQUISITION

SOURCES

Data for the land use inventory was obtained from 1970 aerial photography of the land encompassed within the 30 NEF contours of each of the three airports. The photographs had a nominal scale of 1" = 1,000', but because the photographs were perspective projections they did not give an orthogonal view. Consequently, there was some variation in the scale of the photographs. For purposes of the analysis, it was not considered necessary to adjust for the scale variation.

In addition to the aerial photography, identification of land use and surface structures, particularly hospitals and schools, was facilitated by the use of U.S.G.S. topographic maps, road maps, and a land use map provided by the Santa Clara County Planning Department. The topographic maps were dated in the late 1950's and early 1960's, but all were photo revised to 1968. The photorevisions had not been field checked.

METHODS

In order to obtain data from aerial photographs in a systematic and thorough manner, a 1/4" grid printed on clear acetate was superimposed over the aerial photographs. Since the scale of the photographs was 1" = 1,000', the grid was equivalent to 250' on the ground, as previously indicated. Each 1/4" square of the coordinate grid contained an area equal to 62,500 square feet or approximately 1.4 acres.

In order to locate the coordinate grid on the aerial photographs, coordinates of the California Plane Coordinate System were first drawn on U.S.G.S. topographic maps of the noise affected areas. Markings for the coordinate system occur along the edges of the maps. With the coordinates drawn on the maps, distinguishing surface fea-

tures, such as edges of buildings or street intersections which lie on the coordinates were noted. These same surface features were then located on the aerial photographs and used as points to construct coordinates on the photographs. The grid was then positioned to the coordinates, an appropriate origin determined, and the cells along the abscissa and ordinate numbered. An illustration of the coordinate grid superimposed over an area adjacent to San Jose Municipal Airport is given on Fig. 8.

Data was collected, first, by identifying each grid square according to its location within the coordinate system and then by assigning the area within it to one of eight land use categories. If more than one land use occurred within a single grid square, assignment to a category was determined by the predominant land use in the area. The land use categories employed, along with a numerical code for computer processing were the following:

0 - water
1 - commercial
2 - airport
3 - vacant
4 - residential
5 - school
6 - hospital
7 - cemetary

Included in the category of commercial land were such activities as community and regional shopping centers, industrial parks, freeways, railroads, parking lots, parks, golf courses, churches, museums, military and agriculture installations. Airport land comprised all the area within the boundary of each airport, including that used for airfield, terminals, and commercial, maintenance, and fixed base operations. Vacant land had no visible structures on its surface, and no alternative identifiable purpose. Vacant land contained within the boundaries of military reservations was classified as commercial. The residential land use cetegory included both single and multiple unit dwellings and the property associated with these

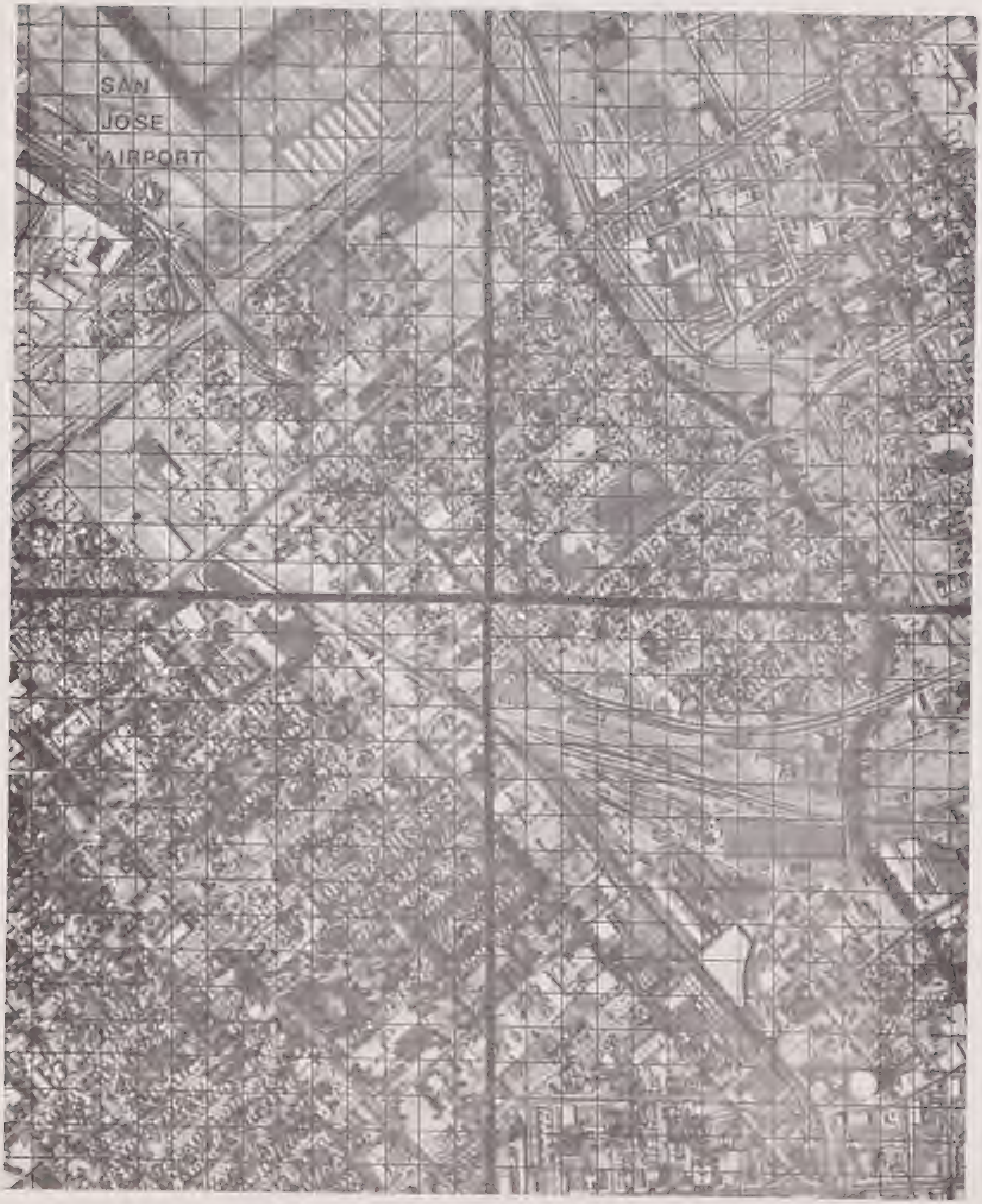


Figure 8. ¼" grid system aligned with the California coordinate system

= Axes of land use inventory coordinate system

units. School land included both buildings and playground areas; and hospital land included both buildings and their grounds. The cemetery land category is self explanatory. The water category included only certain portions of San Francisco Bay immediately adjacent to the shore line. Not all of the water areas encompassed by the noise contours have been included in the land use inventory, and the category has been omitted, with no loss of information, from the listings on Tables 1 through 6 at the end of Section IV.

After each grid square was classified, a count was made of all the residential, hospital, and school buildings contained within the area. If a hospital or school comprised a complex of buildings, they were counted as a single building. Difficulties arose in trying to differentiate on the photographs between multiple unit residences and small commercial buildings, even when the additional sources of land use information were consulted. Extensive foliage concealing parts of structures also made identification difficult in some areas. These problems are potential sources of inaccuracy in the inventory which could only be eliminated by ground checking of the data.

IV. APPLICATIONS AND EXTENSIONS

Certainly the principal, and intended, use of the analytical process reported here is the evaluation of the noise ramifications of alternative airport development policies. But the process is flexible in its application, and has other potential uses in the ABAG planning process.

CURRENT RESULTS

The results of the land use allocation model using 1970 and 1985 noise contours as calculated for San Francisco International, Metropolitan Oakland International, and San Jose Municipal airports are given on Tables 1 through 6 at the end of this section. These tables represent the results of the land use allocation program operated with one set of noise contours. Comparative results can be obtained by making other assumptions about the noise contours and operating the program with these altered assumptions, as discussed in the next section.

USE IN AIRPORT PROJECT APPRAISAL

The principal use of the land use inventory and allocation program lies in its use in appraisal of the noise implications of alternative kinds of airport development projects. There are at least three principal applications. These include the appraisal of effects of (1) new runways on existing airports, (2) alternative

patterns in the distribution of traffic growth among the three major air carrier airports, and (3) the development of new airport sites.

APPRAISAL OF NEW RUNWAY PROPOSALS

New runways on existing airports will have the dual effect of potentially exposing new land areas to noise, and reducing traffic (or the rate of traffic growth) on existing runway complexes.

In the case where a new runway is to be evaluated, frequently the land use inventory will probably require augmentation by data on the land area encompassed by the new noise contours. Typically, however, the data augmentation task should not be extensive since the newly affected area will normally be water, open space, or at least be sparsely developed. Traffic reallocations resulting from the additional runway(s) will tend to reduce the extent of the noise affected area around the existing runway complex as traffic is transferred from the old to the new complex, so the land use inventory for the existing runway complex will normally be sufficient.

If a computer program is used to produce final NEF contours, data on the new runway utilization, together with the land use inventory, augmented where necessary, will provide a rapid estimate of the potential noise alleviation effects of the new runway proposal.

ALTERNATIVE PATTERNS OF TRAFFIC GROWTH

It is obvious that several alternative distributions of traffic growth are possible among the existing or future air carrier airports in the Bay Area. The noise implications of alternative growth patterns can be readily appraised by use of the land use inventory and allocation program. The analytical procedure is essentially that just described, except that traffic allocations are among existing runways. The noise contours implicit in alternative traffic allocations among the three or more airports can be digitized, either by hand methods or directly from the computer program which computes the contours. The digitized noise contour data can then be input into the land use allocation program to analyze the amount of various land uses affected under different alternatives.

NEW AIRPORT SITES

If the analytical procedures decribed here are to be used to evaluate new airport site proposals, it will be necessary to develop a land use inventory for those sites in the same manner as the inventory has been prepared for the three airports discussed in this report. There is, however, no need to retain precisely the same land use categories. In particular, it may, in some cases, be desirable to specially designate agricultural land, or even particular knnds of agricultural land as specific land uses. In addition, areas of special historical, recreational, ecological, or other interest

can also be designated as particular land uses. Some of these land uses may, however, require a ground survey to supplement the more general information obtainable from aerial photography and maps.

OTHER APPLICATIONS

The land use allocation program is versatile in its potential applications. It can allocate any data recorded on a coordinate system to a set of contours or circumscribing lines recorded with respect to that same coordinate system.

Possible applications could include the analysis of properties affected by noise or air polltuion along freeways or major highways; or the analysis of noise or, perhaps, other impacts along BART routes and so forth. The analytical process requires only that all data be recorded with reference to a fixed set of coordinates. The density of the coordinate grid system will depend on the problem to be analyzed. A 250 - foot coordinate grid seems appropriate for the analysis of airport noise in densely developd areas, but a different grid density might be more appropriate for other uses.

Table 4-1

ABAG AIRPORT LAND USE STUDY

SAN FRANCISCO AIRPORT FOR THE YEAR 1970

CONTOUR LEVEL

LAND USE	30-35	35-40	40-45	45+	TOTAL
RESIDENTIAL					
ACRES	2294.00	1043.62	310.22	37.88	3685.72
HOUSE COUNT	14574	6514	1577	156	22822
SCHOOLS					
ACRES	109.00	54.75	14.16	0.	177.92
BUILDING COUNT	24	9	3	0	36
HOSPITALS					
ACRES	2.87	0.	0.	0.	2.87
BUILDING COUNT	1	0	0	0	1
COMMERCIAL					
ACRES	1443.40	1022.04	290.67	96.70	2852.82
VACANT					
ACRES	1996.14	1002.22	93.32	38.95	3130.64
AIRPORT					
ACRES	111.91	173.61	212.35	1357.32	1855.20
CEMETERY					
ACRES	242.48	87.52	43.04	0.	373.05
TOTAL ACRES	6199.81	3383.77	963.77	1530.86	12078.21

Table 4-2

ABAG AIRPORT LAND USE STUDY

SAN FRANCISCO AIRPORT FOR THE YEAR 1985

LAND USE	CONTOUR LEVEL 30-35	35-40	40-45	45+	TOTAL
RESIDENTIAL					
ACRES	1420.43	626.08	76.45	0.	2122.96
HOUSE COUNT	9139	3424	361	0	12924
SCHOOLS					
ACRES	68.88	27.26	0.	0.	96.15
BUILDING COUNT	16	5	0	0	21
HOSPITALS					
ACRES	0.	0.	0.	0.	0.
BUILDING COUNT	0	0	0	0	0
COMMERCIAL					
ACRES	1084.94	618.79	107.80	10.04	1821.58
VACANT					
ACRES	1692.45	256.57	50.54	2.87	2002.43
AIRPORT					
ACRES	203.74	176.48	311.35	896.75	1588.33
CEMETERY					
ACRES	109.04	60.59	6.85	0.	176.48
TOTAL ACRES	4579.49	1765.77	552.99	909.66	7807.92

Table 4-3

ABAG AIRPORT LAND USE STUDY

OAKLAND AIRPORT FOR THE YEAR 1970

LAND USE	CONTOUR LEVEL 30-35	35-40	40-45	45+	TOTAL
RESIDENTIAL					
ACRES	85.76	0.	0.	0.	85.76
HOUSE COUNT	444	0	0	0	444
SCHOOLS					
ACRES	0.	0.	0.	0.	0.
BUILDING COUNT	0	0	0	0	0
HOSPITALS					
ACRES	0.	0.	0.	0.	0.
BUILDING COUNT	0	0	0	0	0
COMMERCIAL					
ACRES	220.68	18.65	1.43	0.	240.77
VACANT					
ACRES	886.71	408.92	40.17	18.65	1354.45
AIRPORT					
ACRES	96.13	76.04	55.96	417.53	645.66
CEMETERY					
ACRES	0.	0.	0.	0.	0.
TOTAL ACRES	1289.28	503.62	97.57	436.18	2326.65

Table 4-4

ABAG AIRPORT LAND USE STUDY

OAKLAND AIRPORT FOR THE YEAR 1985

LAND USE		CONTOUR LEVEL 30-35	35-40	40-45	45+	TOTAL
RESIDENTIAL						
	ACRES	212.91	8.69	0.	0.	221.60
	HOUSE COUNT	1131	42	0	0	1173
SCHOOLS						
	ACRES	15.78	0.	0.	0.	15.78
	BUILDING COUNT	1	0	0	0	1
HOSPITALS						
	ACRES	0.	0.	0.	0.	0.
	BUILDING COUNT	0	0	0	0	0
COMMERCIAL						
	ACRES	671.49	11.48	0.	0.	682.97
VACANT	ACRES	1210.97	439.05	139.18	64.57	1853.76
AIRPORT						
	ACRES	318.53	81.78	81.78	535.18	1017.28
CEMETERY	ACRES	0.	0.	0.	0.	0.
TOTAL ACRES		2429.68	541.00	220.96	599.75	3791.39

Table 4-5

ABAG AIRPORT LAND USE STUDY

SAN JOSE AIRPORT FOR THE YEAR 1970

LAND USE	CONTOUR LEVEL 30-35	35-40	40-45	45+	TOTAL
RESIDENTIAL					
ACRES	360.24	84.58	34.23	10.31	489.35
HOUSE COUNT	1390	317	136	47	1890
SCHOOLS					
ACRES	22.96	5.74	1.43	0.	30.13
BUILDING COUNT	4	1	0	0	5
HOSPITALS					
ACRES	30.13	0.	0.	0.	30.13
BUILDING COUNT	0	0	0	0	0
COMMERCIAL					
ACRES	489.06	222.19	41.78	10.28	763.31
VACANT					
ACRES	156.14	31.57	17.22	0.	204.92
AIRPORT					
ACRES	119.09	110.48	58.83	86.09	374.48
CEMETERY					
ACRES	0.	0.	0.	0.	0.
TOTAL ACRES	1177.61	454.55	153.49	106.68	1892.33

Table 4-6

ABAG AIRPORT LAND USE STUDY

SAN JOSE AIRPORT FOR THE YEAR 1985

LAND USE	CONTOUR LEVEL 30-35	35-40	40-45	45+	TOTAL
RESIDENTIAL					
ACRES	425.52	111.14	28.98	5.37	571.00
HOUSE COUNT	1699	438	108	24	2268
SCHOOLS					
ACRES	33.00	4.30	1.36	.07	38.74
BUILDING COUNT	5	1	0	0	6
HOSPITALS					
ACRES	71.74	1.43	0.	0.	73.17
BUILDING COUNT	0	0	0	0	0
COMMERCIAL					
ACRES	984.21	386.03	117.65	14.35	1502.24
VACANT					
ACRES	219.27	119.09	28.70	4.30	371.36
AIRPORT					
ACRES	90.39	143.48	99.00	165.00	497.88
CEMETERY					
ACRES	0.	0.	0.	0.	0.
TOTAL ACRES	1824.13	765.47	275.69	189.09	3054.39

APPENDIX A

LAND USE ALLOCATION PROGRAM

PREPARED BY

FRED L. COLLINS

COMPUTER PROGRAM WRITEUP

1. IDENTIFICATION

a) TITLE: ABAG02, Airport noise/land use study
b) LANGUAGE AND MACHINE: FORTRAN IV, CDC 6400
c) ANALYSIS AND PROGRAMMING: Mr. Fred L. Collins, Fred L. Collins Associates, 14439 Trinidad Road, San Leandro, CA 94577 (415) 357-5272
d) ORIGINATING ORGANIZATION: Association of Bay Area Governments, Hotel Claremont, Berkeley, CA 94705 (415) 841-9730
e) CONTACT: Mr. Walter E. Gillfillan, Association of Bay Area Governments, Hotel Claremont, Berkeley, CA 94705 (415) 841-9898
f) DATE: October 31, 1971

2. DESCRIPTION:

This program takes land use data and noise contour data and calculates land use area by several criteria. The criteria used in this study were - a breakdown of land use into school land, cemetary land, residential land, airport land, hospital land, vacant land, and commercial land; by noise level.

3. METHOD:

The land use data was hand digitized. Each land use block was a square of 250 feet per side with the Y co-ordinate running from north to south on the California grid system and the X axis running east and west. The chosen centroid was the land use square labeled 500,500 in its north/west corner. Since a land matrix of 1000 x 1000 was set up for the purpose of this study, all land use squares were labeled in the north/west corner and never went negative. Y values became larger as they went north and X values became larger as they went east.

In the case of the noise contours, they were not hand digitized, but could have been. For this study, a CALMA 303 magnetic tape digitizer was used. Maps at a scale of 4000 feet per inch were utilized and controlled by the 500,500 co-ordinate.

Both sets of data were reduced to cards, then sorted and placed separately onto two magnetic tapes which become the input to this program. The output is a one-page table with contour splits across the top and land use building counts and areas along the sides.

4. COMPUTER ANALYSIS:

Although the data for the noise contours could be mechanically digitized, it was felt that this would lock the program system into a fairly sophisticated and expensive piece of equipment (i.e., the CALMA 303 digitizer). This was not desirable for two reasons. First, not very many users would have access to this equipment, and secondly, there were certain programs that translated the magnetic tape output to the CDC 6400 which were privately purchased and would not always be available. Therefore, the data

was mechanically digitized, processed through the PREPOS and CALMA computer programs, interpolated and extrapolated into a series of matrix cuts (see Appendix A), and then dumped onto cards.

The effect of this was to generate cards that had the appearance of hand digitized data. Each square of 250 x 250 feet has the possibility of being linearly cut by the twelve possible cuts shown in Appendix A or not cut at all. These can then be sorted in the following manner. A "from" node, denoted by the dot,cuts the square to the "to" node, denoted by the arrow head. By splitting the contours into the half which generally heads east (plus x) and the other half which generally heads west (minus x), the "from" notes x's can be sorted for the first half and the "to" nodes x's can be sorted for the second half and combined. This means that a vertical set of cuts can be generated for each vertical strip of land use data. For example:

	X "from"	Y "from"	X "to"	Y "to"	
Cut no. 2	347.0	550.3	348.0	550.3	and
Cut no. 8	348.0	347.2	347.0	347.2	

fall into the same vertical strip.

In the case of the computer set up strips, an added value of the mean of X "from" and X "to" was calculated to allow for only one sorting. In this program, a Y sort is not necessary.

When a contour cuts the land use square it increments the contour level counts if the cut is a positive x direction cut (cuts 1, 2, 3, 6, 12, and sometimes 4 and 11) and decrements the counts if it is a cut in the negative x direction (cuts 5, 7, 8, 9, 10, and sometimes 4 and 11). This way levels can build up and down as many times as necessary (note: San Francisco Airport's X values increased and decreased two times each.)

Because of the various criteria placed on this data, the following items were necessary in each cut record.

X "from", Y "from", X "to", Y "to", X direction, Y direction, and contour level

for example: 550.0 547.5 551.0 547.5 +1 ɓ 2

ɓ = blank

This means that this cut sliced the land use square number 550, 548; it was a number 2 cut traveling in the positive X direction (+1); not traveling in the Y direction (ɓ); and is a number 2 contour (1 or 5 = 30, 2 or 6 = 35, 3 or 7 = 40, 4 or 8 = 45; where 1 - 4 is 1970 and 5 - 8 is 1985). This also means that the northern part of this cut is contour level 30 -35 and the southern is 35-40.

The contour cuts, once sorted, are then read and loaded onto tape so that each vertical strip forms a two dimension record of (7,50), where there are seven value (per above) for each cut and up to 50 cuts per strip. Experience has proven that generally there are fewer than twenty cuts per strip.

In the case of the land use data, it was keypunched, sorted by Y value within X values, and loaded onto tape. Its data field per record is six long preceeded by a single vertical strip indicator (e.g., 500 means that this vertical strip has a western X coordinate of 500). It should be noted that since the Y values get larger heading north, the Y sort is an inverse sort.

The land use array is a (6, 1000) with a present maximum of 1000 record or 1,000,000 250 x 250 feet land use square, for a total area of 250,000 feet by 250,000 feet. The six values per land use square are X west, Y north, number of residents, number of schools, number of hospitals, and the designated land use.

For example: 523 472 5 1 Ø 5

means that this is land use square number 523,472 with 5 residential structures, 1 school building, zero (Ø) hospitals, and is land use 5 (school land). Land use codes are as follows:

0 or (Ø)	water (not used)
1	commercial land
2	airport land
3	vacant land
4	residential land
5	school land
6	hospital land
7	cemetary land

5. REFERENCES

None.

6. PROGRAM OPERATING INSTRUCTIONS

This program has only one data card as input and two tapes. That one card is a title card.

Title Card

cc	Name	Identification	Mode/Field
1-80	IT (8)	Title	8A10

Data on tape number 2 (land use) is read in binary into array A (6, 1000) with its vertical strip indicator IV:

READ (2) IV, A

Data tape number 3 (contour tape) is read into array CON (7, 50) which is equivalenced to ICØN (7, 50) along with the contour slice count.

READ (3) IC, CØN

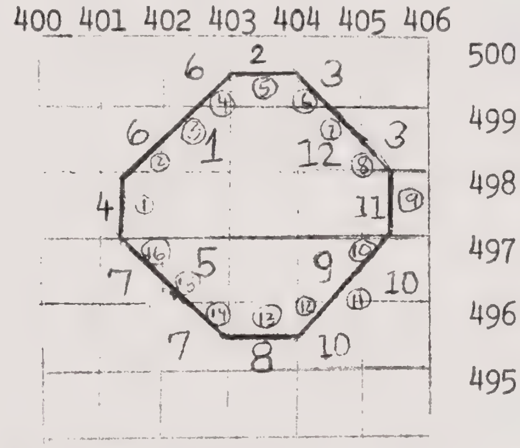
where IC ≤ 50

The A array must be sorted but the CØN array is matched to the A array and therefore does not need to be sorted. This is not as efficient as it would be if CØN were sorted but it saves a great deal of time in the manual sorting process and does not detract that much from the running time.

The following sample data was run for a test with the following results:

X	Y
401	500
401	499
401	498
401	497
401	496
402	500
402	499
402	498
402	497
402	496
403	500
403	499
403	498
403	497
403	496
404	500
404	499
404	498
404	497
404	496
405	500
405	499
405	498
405	497
405	496

LAND USE DATA (without any land use indicators)



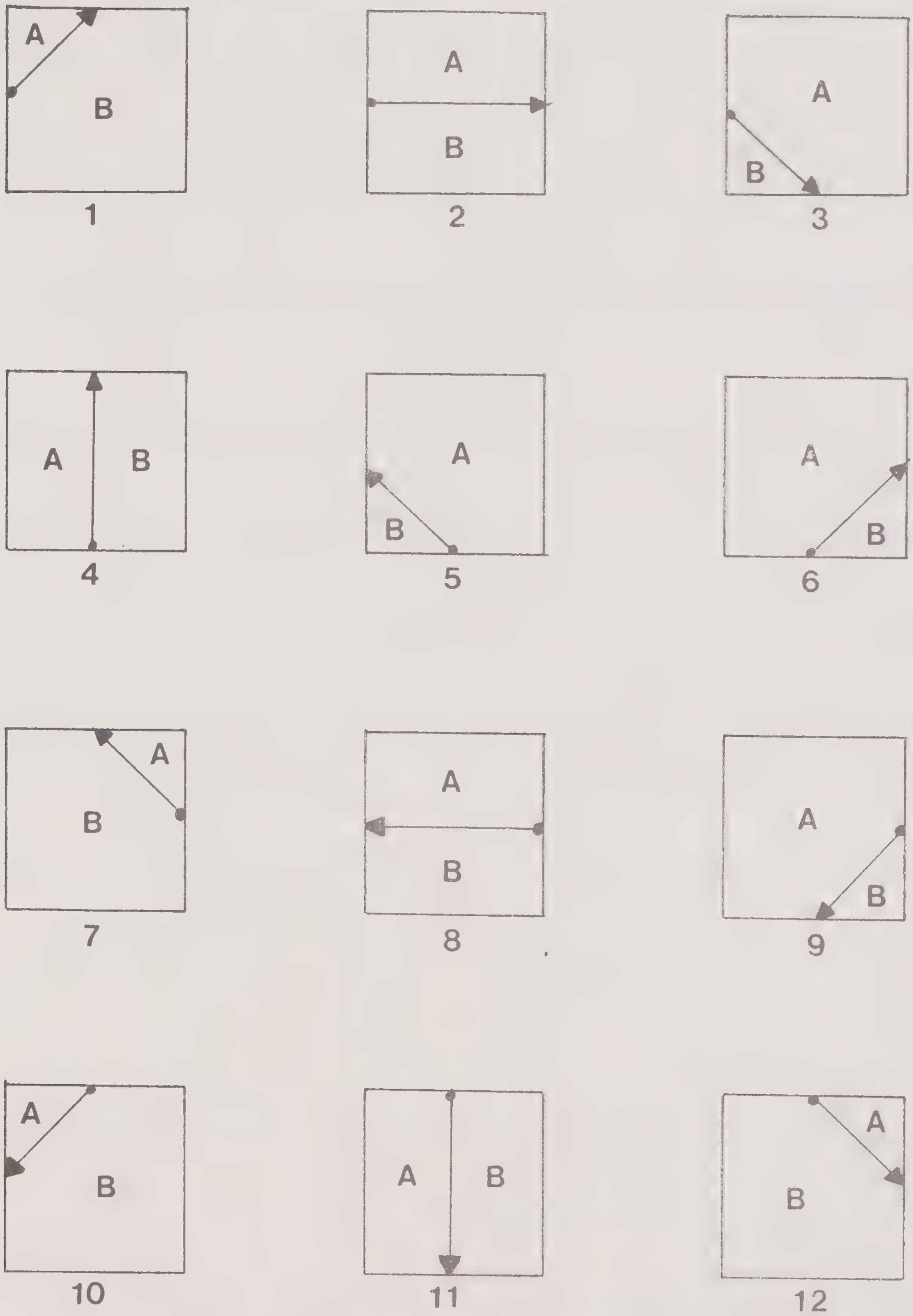
1 numbers of contour record
4 number of the type of cut

CONTOUR DATA (without direction indicators)

	X "from"	Y "from"	X "to"	Y "to"	contour level
1	401.5	497.0	401.5	498.0	1
2	401.5	498.0	402.0	498.5	1
3	402.0	498.5	402.5	499.0	1
4	402.5	499.0	403.0	499.5	1
5	403.0	499.5	404.0	499.5	1
6	404.0	499.5	404.5	499.0	1
7	404.5	499.0	405.0	498.5	1
8	405.0	498.5	405.5	498.0	1
9	405.5	498.0	405.5	497.0	1
10	405.5	497.0	405.0	496.5	1
11	405.0	496.5	404.5	496.0	1
12	404.5	496.0	404.0	495.5	1
13	404.0	495.5	403.0	495.5	1
14	403.0	495.5	402.5	496.0	1
15	402.5	496.0	402.0	496.5	1
16	402.0	496.5	401.5	497.0	1

APPENDIX A

Possible Cuts



OUTPUT

Type of Slice	level	Contour Div.	Input Land			Input Contours						level	Input Land Record No.	Input Contour Record No.	Direction	Percent
0	1	1	401.0	500.0	•	402.0	496.5	401.5	497.0	-0	-0	1	1	16	>	
6	1	1	401.0	499.0	•	401.5	498.0	402.0	498.5	-0	-0	1	2	2	1	.87500
6	1	2	401.0	499.0	•	401.5	498.0	402.0	498.5	-0	-0	1	2	2	1	.12500
4	1	2	401.0	498.0	•	401.5	497.0	401.5	498.0	-0	-0	1	3	1	-1	.50000
4	1	1	401.0	498.0	•	401.5	497.0	401.5	498.0	-0	-0	1	3	1	-1	.50000
7	1	2	401.0	497.0	•	402.0	496.5	401.5	497.0	-0	-0	1	4	16	-1	.12500
7	1	1	401.0	497.0	•	402.0	496.5	401.5	497.0	-0	-0	1	4	16	-1	.87500
0	1	1	401.0	496.0	•	402.0	496.5	401.5	497.0	-0	-0	1	5	16	-1	
6	1	1	402.0	500.0	•	402.5	499.0	403.0	499.5	-0	-0	1	6	4	1	.87500
6	1	2	402.0	500.0	•	402.5	499.0	403.0	499.5	-0	-0	1	6	4	1	.12500
1	1	1	402.0	499.0	•	402.0	498.5	402.5	499.0	-0	-0	1	7	3	1	.12500
1	1	2	402.0	499.0	•	402.0	498.5	402.5	499.0	-0	-0	1	7	3	1	.87500
0	1	2	402.0	498.0	•	402.0	496.5	401.5	497.0	-0	-0	1	8	16	1	
5	1	2	402.0	497.0	•	402.5	496.0	402.0	496.5	-0	-0	1	9	15	-1	.87500
5	1	1	402.0	497.0	•	402.5	496.0	402.0	496.5	-0	-0	1	9	15	-1	.12500
7	1	2	402.0	496.0	•	403.0	495.5	402.5	496.0	-0	-0	1	10	14	-1	.12500
7	1	1	402.0	496.0	•	403.0	495.5	402.5	496.0	-0	-0	1	10	14	-1	.87500
2	1	1	403.0	500.0	•	403.0	499.5	404.0	499.5	-0	-0	1	11	5	1	.50000
2	1	2	403.0	500.0	•	403.0	499.5	404.0	499.5	-0	-0	1	11	5	1	.50000
0	1	2	403.0	499.0	•	402.0	496.5	401.5	497.0	-0	-0	1	12	16	1	
0	1	2	403.0	498.0	•	402.0	496.5	401.5	497.0	-0	-0	1	13	16	1	
0	1	2	403.0	497.0	•	402.0	496.5	401.5	497.0	-0	-0	1	14	16	1	
8	1	2	403.0	496.0	•	404.0	495.5	403.0	495.5	-0	-0	1	15	13	-1	.50000
8	1	1	403.0	495.0	•	404.0	495.5	403.0	495.5	-0	-0	1	15	13	-1	.50000
3	1	1	404.0	500.0	•	404.0	499.5	404.5	499.0	-0	-0	1	16	6	1	.87500
3	1	2	404.0	500.0	•	404.0	499.5	404.5	499.0	-0	-0	1	16	6	1	.12500
12	1	1	404.0	499.0	•	404.5	499.0	405.0	498.5	-0	-0	1	17	7	1	.12500
12	1	2	404.0	499.0	•	404.5	499.0	405.0	498.5	-0	-0	1	17	7	1	.87500
0	1	2	404.0	498.0	•	402.0	496.5	401.5	497.0	-0	-0	1	18	16	1	
9	1	2	404.0	497.0	•	405.0	496.5	404.5	496.0	-0	-0	1	19	11	-1	.87500
9	1	1	404.0	497.0	•	405.0	496.5	404.5	496.0	-0	-0	1	19	11	-1	.12500
10	1	2	404.0	496.0	•	404.5	496.0	404.0	495.5	-0	-0	1	20	12	-1	.12500
10	1	1	404.0	496.0	•	404.5	496.0	404.0	495.5	-0	-0	1	20	12	-1	.87500
0	1	1	405.0	500.0	•	402.0	496.5	401.5	497.0	-0	-0	1	21	16	-1	
3	1	1	405.0	499.0	•	405.0	498.5	405.5	498.0	-0	-0	1	22	8	1	.87500
3	1	2	405.0	499.0	•	405.0	498.5	405.5	498.0	-0	-0	1	22	8	1	.12500
11	1	2	405.0	498.0	•	405.5	498.0	405.5	497.0	-0	-0	1	23	9	-1	.50000
11	1	1	405.0	498.0	•	405.5	498.0	405.5	497.0	-0	-0	1	23	9	-1	.50000
10	1	2	405.0	497.0	•	405.5	497.0	405.0	496.5	-0	-0	1	24	10	-1	.12500
10	1	1	405.0	497.0	•	405.5	497.0	405.0	496.5	-0	-0	1	24	10	-1	.87500
0	1	1	405.0	496.0	•	402.0	496.5	401.5	497.0	-0	-0	1	25	16	-1	

```
      PROGRAM ABAG02 (INPUT,OUTPUT,TAPE2,TAPE3)
C --- THIS PROGRAM IS THE FINAL OUTPUT PROGRAM
C ---   IT USES THE TAPE 2 (LAND USE)
C ---     AND TAPE3 CONTOURS)
      DIMENSION A(6,1000),OUT(4,8,5),CON(7,50),ICON(7,50)
      EQUIVALENCE (CON,ICON)
      IDEBUG=1
      IDEBUG=0
      DO 2 I=1,4
      DO 2 J=1,8
      DO 2 K=1,5
      OUT(I,J,K)=0.0
    2 CONTINUE
C --- READ THE FIRST -A- RECORD (LAND USE RECORDS)
      READ (2) IV,A
      VI=IV+1
C --- READ THE FIRST -CON- RECORD (CONTOUR VERTICAL STRIPS)
    5 READ (3) IC,CON
             IF (IDEBUG.EQ.1)
     1PRINT 1020,IV,VI,(A(I,1),I=1,6),IC, CON(1,1),CON(2,1),CON(3,1),
     1 CON(4,1),ICON(5,1),ICON(6,1),ICON(7,1)
 1020 FORMAT (I5,7F6.1,I5,4F6.1,3I5)
      IF (  VI  .LE.CON(1,1).AND.(  VI  +1.).GE.CON(1,1)) GO TO 10
      IF (  VI  .GT.CON(1,1)) GO TO 5
      PRINT 1000
      CALL EXIT
C --- START PROCESSING ,  THE CONTOURS AND THE LAND USE RECORDS ARE
C ----      ALIGNED
   10 IST=1
C --- FOR SAN FRANCISCO 1970 ICON(7,I)=ICON(7,I)-1
      DO 13 I=1,IC
      ICON(7,I)=ICON(7,I)-1
   13 CONTINUE
      ILEV=1
      DO 100 J=1,1000
      IF (A(1,J).LE.0.0) GO TO 100
      IF (A(2,J).LE.0.0) GO TO 100
      IF (A(1,J).GT.0.0.AND.A(1,J).LE.1000.) A(2,J)=A(2,J)+1.
      LUS =A(6,J)+1.
      DO 15 II=1,IC
      IST=II
      IF (A(2,J).GE.CON(2,IST).AND.(A(2,J)-1.).LE.CON(2,IST).AND.
     1    A(2,J).GE.CON(4,IST).AND.(A(2,J)-1.).LE.CON(4,IST)) GO TO 14
      GO TO 15
   14 IF (A(1,J).LE.CON(1,IST).AND.(A(1,J)+1.).GE.CON(1,IST).AND.
     1    A(1,J).LE.CON(3,IST).AND.(A(1,J)+1.).GE.CON(3,IST)) GO TO 20
   15 CONTINUE
C --- THIS LAND USE IS NOT SPLIT BY A CONTOUR LINE
      ITYPE=0
             IF (IDEBUG.EQ.1)
     1PRINT 1030,ITYPE,LUS,ILEV,(A(II,J),II=1,6),(CON(II,IST),II=1,4),
     1 (ICON(II,IST),II=5,7),J,IST,IADD
 1030 FORMAT (3I5,6F8.1,4F6.1,6I5,F10.5)
      OUT(1,LUS,ILEV)=OUT(1,LUS,ILEV)+1.
      OUT(2,LUS,ILEV)=OUT(2,LUS,ILEV)+A(3,J)
      OUT(3,LUS,ILEV)=OUT(3,LUS,ILEV)+A(4,J)
      OUT(4,LUS,ILEV)=OUT(4,LUS,ILEV)+A(5,J)
      GO TO 100
```

```
C --- WHICH OF THE TWELVE POSSIBLE CUTS IS THIS ONE
   20 IF ((A(2,J)-1.).EQ.CON(2,IST)) GO TO 40
      IF ((A(1,J)+1.).EQ.CON(1,IST)) GO TO 60
      IF (A(2,J).EQ.CON(2,IST)) GO TO 80
C --- IS THIS A 1,2, OR 3
      IF ((A(1,J)+1.).EQ.CON(3,IST)) GO TO 30
      IF ((A(2,J)-1.).EQ.CON(4,IST)) GO TO 35
C --- IT IS A TYPE 1
      PCT=.5*(CON(3,IST)-A(1,J))*(A(2,J)-CON(2,IST))
      ILEV=ICON(7,IST)
      ITYPE=1
   21 IADD=1
   22 DO 25 K=1,2
      PRINT 1030,ITYPE,LUS,ILEV,(A(II,J),II=1,6),(CON(II,IST),II=1,4),
     1 (ICON(II,IST),II=5,7),J,IST,IADD,PCT
      IF (ILEV.LT.1) ILEV=1
      IF (ILEV.GT.5) ILEV=5
      OUT(1,LUS,ILEV)=OUT(1,LUS,ILEV)+PCT
      OUT(2,LUS,ILEV)=OUT(2,LUS,ILEV)+PCT*A(3,J)
      OUT(3,LUS,ILEV)=OUT(3,LUS,ILEV)+PCT*A(4,J)
      OUT(4,LUS,ILEV)=OUT(4,LUS,ILEV)+PCT*A(5,J)
      IF (K.EQ.2) GO TO 95
      ILEV=ILEV+IADD
      IF (ILEV.LT.1) ILEV=1
      IF (ILEV.GT.5) ILEV=5
      PCT=1.-PCT
   25 CONTINUE
      GO TO 100
C --- IT IS A TYPE 2
   30 PCT=.5*((A(2,J)-CON(2,IST))+(A(2,J)-CON(4,IST)))
      ILEV=ICON(7,IST)
      ITYPE=2
      GO TO 21
C --- IT IS A TYPE 3
   35 PCT=1.-(.5*(CON(3,IST)-A(1,J))*(CON(2,IST)-(A(2,J)-1.)))
      ILEV=ICON(7,IST)
      ITYPE=3
      GO TO 21
C --- IS THIS ONE A TYPE 4,5, OR 6
   40 IF (A(1,J).EQ.CON(3,IST)) GO TO 50
      IF ((A(1,J)+1.).EQ.CON(3,IST)) GO TO 55
C --- IT IS A TYPE 4
      PCT=.5*((CON(1,IST)-A(1,J))+(CON(3,IST)-A(1,J)))
      ILEV=ICON(7,IST)
      ITYPE=4
      IADD=CON(5,IST)
      IF (IADD.EQ.0) IADD=-1
      IF (IADD.EQ.(-1)) ILEV=ILEV+1
      GO TO 22
C --- IT IS A TYPE 5
   50 PCT=1.-(.5*(CON(1,IST)-A(1,J))*(CON(4,IST)-(A(2,J)-1.)))
      ILEV=ICON(7,IST)+1
      ITYPE=5
      IADD=-1
      GO TO 22
C --- IT IS A TYPE 6
   55 PCT=1.-(.5*((A(1,J)+1.)-CON(1,IST))*(CON(4,IST)-(A(2,J)-1.)))
      ILEV=ICON(7,IST)
```

```
      ITYPE=6
      GO TO 21
C --- IS THIS A TYPE 7,8, OR 9
   60 IF (A(1,J).EQ.CON(3,IST)) GO TO 70
      IF ((A(2,J)-1.).EQ.CON(4,IST)) GO TO 75
C --- IT IS A TYPE 7
      PCT=.5*(A(1,J)+1.-CON(3,IST))*(A(2,J)-CON(2,IST))
      ILEV=ICON(7,IST)+1
      ITYPE=7
      IADD=-1
      GO TO 22
C --- IT IS A TYPE 8
   70 PCT=-.5*((CON(4,IST)-A(2,J))+(CON(2,IST)-A(2,J)))
      ILEV=ICON(7,IST)+1
      ITYPE=8
      IADD=-1
      GO TO 22
C --- IT IS A TYPE 9
   75 PCT=1.-(.5*(CON(2,IST)-(A(2,J)-1.))*((A(1,J)+1.)-CON(3,IST)))
      ILEV=ICON(7,IST)+1
      ITYPE=9
      IADD=-1
      GO TO 22
C --- IS THIS A TYPE 10,11, OR 12
   80 IF ((A(2,J)-1.).EQ.CON(4,IST)) GO TO 85
      IF ((A(1,J)+1.).EQ.CON(3,IST)) GO TO 90
C --- IT IS A TYPE 10
      PCT=.5*(CON(1,IST)-A(1,J))*(A(2,J)-CON(4,IST))
      ILEV=ICON(7,IST)+1
      ITYPE=10
      IADD=-1
      GO TO 22
C --- IT IS A TYPE 11
   85 PCT=.5*((CON(1,IST)-A(1,J))+(CON(3,IST)-A(1,J)))
      ILEV=ICON(7,IST)
      ITYPE=11
      IADD=CON(5,IST)
      IF (IADD.EQ.0) IADD=-1
      IF (IADD.EQ.(-1)) ILEV=ILEV+1
      GO TO 22
C --- IT IS A TYPE 12
   90 PCT=.5*((A(1,J)+1.)-CON(1,IST))*(A(2,J)-CON(4,IST))
      ILEV=ICON(7,IST)
      ITYPE=12
      GO TO 21
C --- END OF THE CONTOUR SPLITTING
   95 IST=IST+1
      ISPLIT=J
  100 CONTINUE
      READ (2) IV,A
      VI=IV+1
      IF (IV.GE.669) CALL OUTFC (OUT)
      IF (A(1,1).EQ.9999.) CALL OUTFC (OUT)
      GO TO 5
C --- FORMAT SECTION
 1000 FORMAT (* DATA OUT OF ORDER*)
      END
```

```
      SUBROUTINE OUTFC (OUT)
      DIMENSION OUT(4,8,5),IT(8),ITT(2)
      DIMENSION TA(5),VSUM(11)
C --- THIS IS THE OUTPUT ROUTINE
      READ 1000,IT
      ACRES=62500./43560.
      DO  50 K=1,5
      TA(K)=0.
      DO 50 J=1,8
      OUT(1,J,K)=OUT(1,J,K)*ACRES
      IF (J.EQ.1) GO TO 50
      TA(K)=TA(K)+OUT(1,J,K)
   50 CONTINUE
      PRINT 1001,IT
      PRINT 1002
      DO 75 J=1,8
      VSUM(J)=0.
      DO 75 K=2,5
      VSUM(J)=VSUM(J)+OUT(1,J,K)
   75 CONTINUE
      VSUM(9)=0.
      VSUM(10)=0.
      VSUM(11)=0.
      DO 100 K=2,5
      VSUM(9)=VSUM(9)+OUT(2,5,K)
      VSUM(10)=VSUM(10)+OUT(3,6,K)
      VSUM(11)=VSUM(11)+OUT(4,7,K)
  100 CONTINUE
      PRINT 1004,(OUT(1,5,K),K=2,5),VSUM(5),(OUT(2,5,K),K=2,5),VSUM(9)
      PRINT 1005,(OUT(1,6,K),K=2,5),VSUM(6),(OUT(3,6,K),K=2,5),VSUM(10)
      PRINT 1006,(OUT(1,7,K),K=2,5),VSUM(7),(OUT(4,7,K),K=2,5),VSUM(11)
      PRINT 1007,(OUT(1,2,K),K=2,5),VSUM(2)
      PRINT 1008,(OUT(1,4,K),K=2,5),VSUM(4)
      PRINT 1009,(OUT(1,3,K),K=2,5),VSUM(3)
C --- PRINT 1010,(OUT(1,1,K),K=2,5),VSUM(1)
      PRINT 1011,(OUT(1,8,K),K=2,5),VSUM(8)
      TAA=0.
      DO 110 K=2,5
      TAA=TAA+TA(K)
  110 CONTINUE
      PRINT 1020,(TA(K),K=2,5),TAA
      CALL REWUNL (2)
      CALL REWUNL (3)
      CALL EXIT
C --- FORMAT (SECTION)
 1000 FORMAT (8A10)
 1001 FORMAT (1H1////  15X,*ABAG AIRPORT LAND USE STUDY*//10X,8A10)
 1002 FORMAT (//44X,*CONTOUR LEVEL*//6X,*LAND USE*,15X,*   30-35        35
     1-40       40-45        45+*/76X,*TOTAL*//1X,80(1H*)//)
 1004 FORMAT (//6X,*RESIDENTIAL*/15X,*ACRES*,6X,5F11.2//13X*HOUSE COUNT*
     1,2X,5F11.0/)
 1005 FORMAT (//6X,*SCHOOLS*/15X,*ACRES*,6X,5F11.2//13X,*BUILDING COUNT*
     1,F10.0,4F11.0)
 1006 FORMAT (//6X,*HOSPITALS*/15X,*ACRES*,6X,5F11.2//13X,*BUILDING COUN
     1T*,F10.0,4F11.0/)
 1007 FORMAT (//6X,*COMMERCIAL*/15X,*ACRES*,6X,5F11.2/)
 1009 FORMAT (//6X,*AIRPORT    */15X,*ACRES*,6X,5F11.2/)
 1010 FORMAT (//6X,*WATER      */15X,*ACRES*,6X,5F11.2/)
```

```
1011 FORMAT (//6X,*CEMETERY  */15X,*ACRES*,6X,5F11.2/)
1008 FORMAT (//6X,*VACANT    */15X,*ACRES*,6X,5F11.2/)
1020 FORMAT (//6X,*TOTAL ACRES*,09X,5F11.2)
1003 FORMAT (45X,*  RESIDENTIAL      SCHOOL          HOSPITAL*/30X,
    1 *      ACRES      *,3(5X,*COUNT*,5X)/5X,*LAND USE*//1X,89(1H*)//
    2* 3 WATER*,17X,F15.2,3F15.0/* 1 COMMERCIAL LAND*, 7X,F15.2,3F15.0/
    3 * 2 AIRPORT LAND*,10X,F15.2,3F15.0/* 3 VACANT LAND*11X,F15.2,3F15
    4 .0/* 4 RESIDENTIAL LAND*,06X,F15.2,3F15.0/* 5 SCHOOL LAND*,11X,
    5 F15.2,3F15.0/* 6 HOSPITAL LAND*,09X,F15.2,3F15.0/* 7 CEMETERY LAN
    6D*,09X,F15.2,3F15.0)
      END
```